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C O N T E N T S

INTRODUCTION (1)

Technological progress prompts changes in the characteristics and the quality of a broad range of products. The traditional techniques for measuring prices are often not able to discount these changes in quality, at least in their entirety. As a result, they often give rise to an overestimation of the price trend and to an underestimation of the expenditure or output figures, in real terms, obtained from the deflation of nominal values by means of these overestimated price indicators.

This paper is part of a research project on the implications of changes in quality and the emergence of new products for the measurement of inflation and growth (2). Its aim is, indeed, to approximate for the Spanish case the scale of the biases potentially being incurred in the estimates of the growth rates of the demand and output deflators, and of the changes in real terms, due to the absence of – or to an insufficient – adjustment of prices to changes in the quality of certain products. An aggregate exercise (3) is thus conducted, consisting of estimating the effect on the growth rates of demand and output deflators of introducing quality-adjusted prices for certain goods and services, and simulating the consequences this would have for the real growth rates of these macroeconomic variables.

The measurement problems associated with the lack of adjustment for quality in price indices are particularly significant in those goods and services where technological progress prompts frequent changes in the characteristics and in the quality of market products. The products belonging to the so-called information and communication technologies (ICT hereafter) are a case in point given the intensity of the technological advances made in recent years and, consequently, the calculation of quality-adjusted price indices is extremely relevant here. In particular, the evi-

(1) We thank INE for their co-operation and the information provided. We also gratefully acknowledge the comments and suggestions by L.J. Álvarez, J.M. Bonilla, O. Bover, J.J. Camio and P. L'Hotellerie.

(2) See Banco de España (2001).

(3) Similar to that performed by Schreyer (1998).

dence available for the computers and peripheral equipment sector [obtained through the application of hedonic methods (4)] show annual average decreases in prices of between 10 % and 40 % per year when the appropriate quality adjustments are made. The potential significance of these adjustments for the performance of certain relevant macroeconomic variables can be seen in Chart 1. This refers to the US economy where, applying an hedonic method, the deflator of investment in computers and peripheral equipment declined between 1986 and 1999 at an average rate of 15.8 % per year. However, with the use of more traditional techniques, which do not fully discount the changes in quality, the declines are much lower.

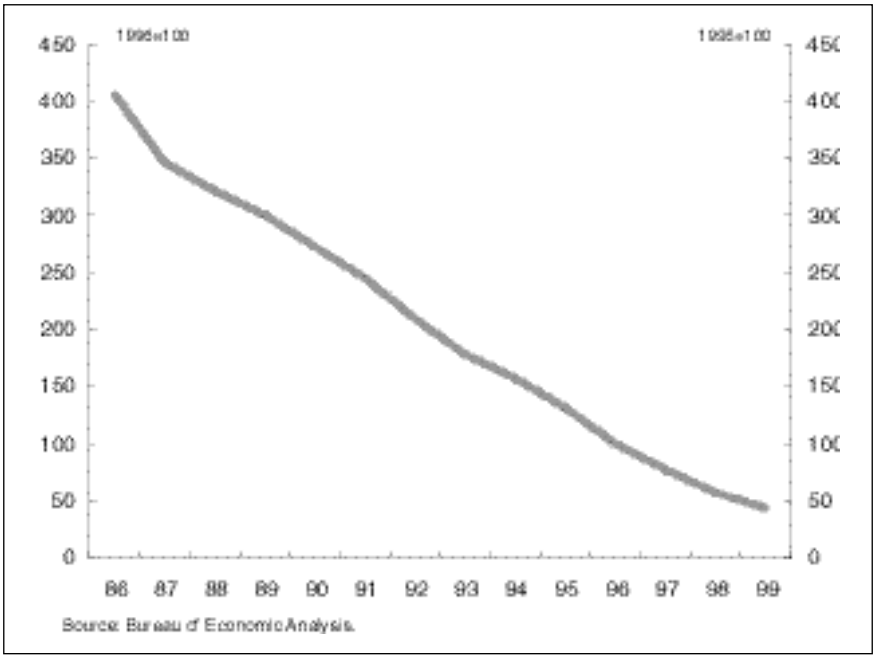
Cars and housing are also products subject to substantial quality changes (albeit on a lesser scale than ICT products), and their relative significance in the Spanish economy means that the adjustment of their price indices for changes in quality is important. The paper has thus selected these three types of products – ICT, cars and housing – to make quality adjustments in their price indices and to estimate their aggregate impact on macroeconomic magnitudes. The improvements in quality that might have occurred in other goods and services (and which are not sufficiently discounted in price indices) are not taken into account; nor is regard had to the losses in quality that may have affected other series of products (cases in point being the possible deterioration in the provision of certain services such as air transport or retailing), which might have effects on macroeconomic variables contrary to those of quality improvements. These considerations should be borne in mind on assessing the results of this preliminary research in terms of output growth and demand.

Given the absence of estimates of quality-related biases in Spain, the empirical studies available for other countries on the scale of the overestimation of traditional price indices are used in this exercise. Once specific studies are available for each sector in the Spanish case, the calculations performed in this paper may be reconsidered. The analysis is conducted with information spanning the period 1986-1994, both because of the greater length of the sectoral data series available (drawn from the Input-Output tables) and to make comparison with the results for other countries easier.

(4) Hedonic price indices are based on the estimation of the relationship between the price of a good and a set of its characteristics that define its quality. They are therefore useful for segregating that portion of price increases due to quality improvements from pure price changes. EUROSTAT (1999) recommends the use of hedonic methods in the computers and peripheral equipment sector, and a defence can be found in Landefeld and Grimm (2000) of the robustness of their results in the United States, where they have been used in official statistics since 1985. Bover and Izquierdo (2001) provide a detailed summary of hedonic studies focused on this sector.

CHART 1

DEFLATOR OF INVESTMENT IN COMPUTERS AND PERIPHERAL EQUIPMENT IN THE UNITED STATES



Rounding off the exercise are two extensions. The first performs a sensitivity analysis of the results, applying adjustments of differing sizes to those of the basic exercise. And the second compares the results with those obtained in a paper by P. Schreyer for certain OECD countries [see Schreyer (1998)], which focuses solely on ICT goods and services. Likewise, the Spanish results are set against those of the Eurostat (1999) paper, which applies a quality adjustment to the computer sector for three Community countries.

I

ANALYTICAL FRAMEWORK

As mentioned, the aim of this exercise is to calculate the effects on real GDP growth rates of adjusting the price indices of certain sectors for quality. To do this, a simulation exercise is performed, based on the sectoral disaggregation used in the final uses matrix of the Input-Output Tables (IOT). The relative significance of the sectors considered and the scale of the adjustments needed to take quality improvements into account delimit the scale of the aggregate impact on macroeconomic magnitudes. That said, this impact will increase: *a)* the greater the proportion of the total output of the sectors earmarked for final demand compared with that for inputs, since an upward correction of the rate of change of inputs only causes changes in the sectoral allocations of output, without affecting GDP; and *b)* the greater the portion of the sector's output produced in the country, as opposed to imported output, since any correction applied to the real output figures of the sectors analysed should also be applied to imports, with the subsequent reduction in real GDP. Lastly, it should be borne in mind that a Laspeyres-type quantities index, such as that traditionally used in National Accounts, normally tends to bias estimates of growth figures upwards since it uses the prices of the baseline year for the aggregation of the real amounts. As a result it does not take into account the changes in the weights that would arise from the changes in relative prices. On introducing quality adjustments into the price indices of certain sectors, the changes in relative prices are very marked and this bias will be all the more significant. Fisher-type superlative quantities indices are particularly to be recommended in this context, and their use will partly reduce the upward correction of the aggregate growth figures.

The aggregate effects on the real GDP growth figure that result from applying quality adjustments to the price indices of certain products are calculated from the standpoint of demand (or of expenditure). This enables the differential effect on each GDP component (consumption, in-

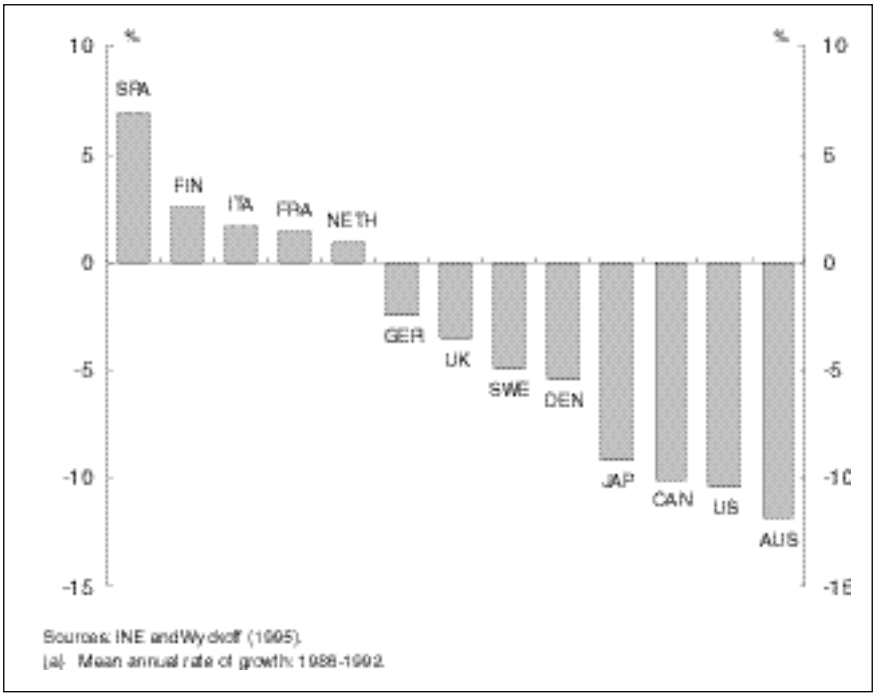
vestment, exports and imports) to be studied and, moreover, it prevents the need for adjustments not only in the value of output of each branch but also in inputs, where such adjustments would be necessary if the exercise were tackled from the standpoint of value added.

The first step of the exercise involves introducing a downward correction into the observed annual average growth rates of the selected output deflator (this is warranted by the existence of quality improvements which have not been taken into account in the original deflator). The magnitude of the correction has been drawn from the empirical evidence available in other countries for each such product. Once these adjustments have been made to the goods and services deflators considered, the nominal values of spending on these products are deflated by the adjusted prices and new values for real expenditure are obtained. These real expenditure figures are aggregated in order to calculate new real values for each of the GDP components, which will differ to a greater or lesser extent from the initial values depending on the weight in each of them of the goods and services considered and on the magnitude of the adjustments applied. In turn, the new real components of GDP are aggregated to calculate the effects on the real growth rate of the economy. Appendix I offers a detailed summary of the methodology used in these calculations. The differences arising from using a Laspeyres-type quantities index or a Fisher index in the aggregation of the various expenditure items are also discussed. Appendix II details the information set used to perform the exercise. The original information is from the IOT and consists of current-price annual expenditure on each GDP component (consumption, investment, exports and imports) with a breakdown of 56 productive branches. The information from a series of other surveys, used to obtain a more detailed breakdown than that available at the maximum level of disaggregation of the IOT, is also presented. The construction of the related deflators at this maximum level of disaggregation is described, using the information from a series of price indicators. That enables the various real-terms items to be expressed, given that the information from the IOT is only in nominal terms.

Regarding the adjustments applied to the deflators of these items, the empirical evidence available has found the biggest biases in the measurement of computer prices, [see, for example, the references in Triplett (1989), Schreyer (1998), Landefeld and Grimm (2000) or the summary of the hedonic estimates available for this sector in Table II.2 of Bover and Izquierdo (2001)]. Generally, the empirical studies that have constructed hedonic price indices for computers have encountered annual declines in these price indices ranging from 10 % to 40 %, depending on the period and the types of computers considered. However, less evidence is available on the difference between the rate of change of a price index calcu-

CHART I.1

DEFLATORS OF VALUE ADDED IN THE OFFICE MACHINERY AND COMPUTERS SECTOR (a)



Sources: INE and Wyckoff (1995).
(a) Mean annual rate of growth: 1988-1992.

lated using a traditional method and that of an hedonic index. Table II.2 of Bover and Izquierdo (2001) indicates that the few studies available, all of which are for the United States, estimate a 10-15 % difference per year between a price index calculated using a matched model method (1) and an hedonic index.

When it comes to applying an adjustment to computer price indices for the Spanish case, the adjustment will hinge crucially on the traditional method used. Chart I.1 shows the great international dispersion exhibited by the deflator of the office equipment and computer sector (2) dur-

(1) This method consists of calculating the increase in prices between two periods as the change in the prices of those products that are on the market both periods without any change in their characteristics. This is one of the traditional methods applied by the various statistical offices to address the measurement problems associated with product quality changes.

(2) The Spanish data are from INE, the Spanish Statistics Office. The source for the other countries is Wyckoff (1995). The latter paper shows how the use of a common deflator for all the countries eliminates much of the divergence across countries in the real growth of labour productivity in the office equipment and computers sector.

ing the period 1986-92. In those countries using hedonic methods during this period, namely Australia, Canada and the United States, there are average annual declines of around 10 %; in the European countries using more traditional techniques, meanwhile, the declines are far lower or price increases are even observed. In this respect, the differences between the price performance in the United States – where hedonic methods are applied – and Spain may be indicative of the scale of the quality bias in our country. In particular, the value-added deflator for the Spanish office equipment and computers sector posted annual growth of 7 % during the period 1986-92, while the same deflator in the United States, calculated with hedonic techniques, fell by 10.4 % per year, i.e. there was a difference between both deflators of 17 percentage points per year.

Nonetheless, before adopting a specific figure to adjust Spanish price indices, it must be remembered that some of the difference is not the outcome of the use of different methodologies in the construction of the price index but is rather attributable to other causes. For one thing, the aggregate behaviour of prices in both countries has differed (the GDP deflator grew three percentage points more a year in Spain than in the United States in this period). For another, the sector's product composition might have been biased in Spain towards lower-technology products than in the United States. Such considerations advise adopting an adjustment of less than 17 %. Specifically, a 10 % adjustment has been made as this is what Schreyer (1998) in his exercise for five OECD countries and Eurostat in an exercise for three European countries both use, and because it can be understood as a cautious estimate of the possible bias in the Spanish case.

For the remaining ICT products included in this paper, the empirical evidence available is less abundant. Significantly, included in the manufacture of electrical and electronic equipment is the manufacture of semiconductors, where the price declines estimated with hedonic methods are even heavier than those estimated for computers. That would entail applying an adjustment to its deflator of at least 10 % (3). Also included in this branch are other ICT products, such as TVs, radios and videos, and communications equipment, along with other non-ICT products, including the manufacture of household appliances. For these products, the empirical studies available have estimated annual differences between traditional and hedonic price indices of between 3 % and 6 % (4). Nonetheless, the breakdown needed to separate ICT products from other electri-

(3) See, for example, Triplett (1996).

(4) Gordon (1990) finds a quality bias of 3 % per year in household appliances and of 6 % in radios and televisions, while Boskin *et al.* (1996) estimate a quality bias of 3 % for household appliances and of 4 % for video and sound equipment.

cal and electronic equipment is not available in this exercise. Therefore, it has been decided to apply a lower adjustment of 2 % per year to this branch in its entirety (5). The same adjustment is applied to communications services. This sector is one of the biggest investors in high-technology products and, although empirical evidence does not abound [see Schreyer (1996)], the improvements in quality appear to have been significant and not included in the price indices normally used for the sector. In his study for five OECD countries, Schreyer (1998) also applies a 2 % adjustment.

A 2 % downward adjustment is also applied to the annual average growth rate of the price index of the vehicles price index. Cars have undergone significant quality improvements (6), although the hedonic estimates available for the US do not seem capable of capturing them in their entirety (7). As a result, only for certain periods does an hedonic price index grow below the official price index. This firstly reflects the difficulties encountered in most studies in obtaining the relevant variables defining car quality. And it further highlights the fact that the price index calculated by the Bureau of Labour Statistics includes a most significant range of quality adjustments, although they are based on cost estimates provided by producers and not on hedonic methods.

Lastly, an adjustment of one percentage point is applied to the annual average growth rate of the residential property price index. Previous studies provide widely differing magnitudes [see Table II.4 in Bover and Izquierdo, (2001)], to the extent even of obtaining losses in quality for short periods. Nevertheless, the introduction of a downward adjustment to the deflator is warranted by the house construction quality gains found in empirical studies when sufficiently lengthy periods are analysed. These quality improvements are not reflected by the deflators, which are usually based on construction costs. For the Spanish case, Arévalo (1998) calculates a Spanish housing quality index in 1980 and 1990, finding significant improvements in the average quality of housing. True,

(5) In Schreyer (1998) the 2 % adjustment is not applied uniformly to all the products of the electrical and electronic equipment branch. In those countries where the data available allow it, a distinction is drawn between electronic components and integrated circuits (with an adjustment of 10 %), the manufacture of electrical equipment, video, sound and communications equipment and measuring devices (with an adjustment of 2 %) and other electrical equipment (without any adjustment). This breakdown could have been made for the Spanish case with the Industry Survey, but not with the Quarterly Family Expenditure Survey or with Customs Records. Accordingly, it was decided here to retain a common adjustment of two percentage points for the entire electrical and electronic equipment branch.

(6) In the form of technological improvements making for lower energy consumption, lower pollution, increased safety (ABS, airbags, etc.), comfort (power steering, air conditioning, etc.), performance, etc.

(7) See Table II.3 of Bover and Izquierdo (2001).

this author does not calculate a price index adjusted for these improvements in quality; but insofar as the price index of the sector has not been calculated adjusting for quality changes, there will be appreciable differences in its rate of change compared with that of a quality-adjusted index.

II

EMPIRICAL RESULTS

Table II.1 shows for each GDP component the estimated weight of expenditure at current prices on each of the products considered in the exercise. As earlier mentioned (and as detailed in Appendix II, the structure has been obtained drawing on the basic information provided by the IOT, with an additional breakdown for certain branches using the supplementary statistics detailed in Table A.II.1 of Appendix II.

As can be seen in the table, the weight of the items related to ICT products (1) in consumption is low. They are products geared mainly to investment and, to a lesser extent, to exports, and their high relative weight in imports is worth noting. Vehicles are also prominent in all GDP components, while residential property accounts for almost 20 % of the economy's total investment. Overall, the items belonging to the selected sectors represent almost 10 % of the Spanish economy's GDP. During the period 1986-1994, the relative weight of this group of goods and services in the nominal magnitudes of the Spanish economy scarcely changed; if anything it declined slightly.

In each case, the price indicators detailed in Table A.II.2 of Appendix II are used as deflators of expenditure at current prices (2). According to the information from these indicators, the price performance of the selected products between 1986 and 1994 is as summarised in Table II.2. As can be seen, the prices of these goods and services generally grew below the deflators of the GDP components. Table A.III.1 of Appendix III

(1) Note that, owing to information problems, the ICT include certain products not belonging to this sector, such as household appliances. However, these products have also undergone quite significant changes in quality.

(2) Basically, information has been drawn from the consumer prices index to deflate the domestic consumption items, from the producer price index to deflate national investment (except for residential property, for which an implicit National Accounts deflator is available), and from the unit value indices to deflate foreign investment and imports and exports.

TABLE II.1

ITEMS INCLUDED IN THE ADJUSTMENTS
PERCENTAGE OF GDP COMPONENTS AT CURRENT PRICES

Items	Consumption		Investment		Exports		Final demand		Imports		GDP	
	1986	1994	1986	1994	1986	1994	1986	1994	1986	1994	1986	1994
Office machinery and computers	0.15	0.10	3.21	2.27	1.60	1.23	0.85	0.60	3.94	2.91	0.33	0.11
Precision instruments	0.11	0.13	1.78	1.70	0.53	0.77	0.45	0.52	2.44	2.25	0.11	0.14
Electrical and electronic equipment	0.97	0.88	6.03	5.65	3.52	5.47	2.15	2.33	6.84	7.98	1.35	1.13
Telecommunications	0.64	0.85	0.00	0.00	0.72	0.41	0.54	0.64	0.16	0.22	0.61	0.73
Vehicles	2.36	2.28	6.37	5.77	11.38	18.48	4.17	5.24	6.83	12.55	3.72	3.69
Residential property	0.00	0.00	19.36	18.41	0.00	0.00	3.31	3.05	0.00	0.00	3.87	3.70
Total	4.23	4.22	36.76	33.81	17.76	26.36	11.48	12.37	20.21	25.91	9.99	9.50

Source: Banco de España

shows how, in real terms, the relative significance of these products in the Spanish economy increased during this period.

Since the weight of the products analysed is greater in investment and in foreign trade, it is these expenditure components whose deflator is most affected by the adjustments made. Applying quality adjustments to price indices involves re-estimating upwards the expenditure on each good in real terms, since the same nominal expenditure is now deflated by a price index with lower growth. Table A.III.2 of Appendix III provides the weights of the products considered in the macroeconomic aggregates at 1986 constant prices, after the adjustments. To obtain the aggregate effect of these adjustments, the adjusted expenditure components in real terms are first calculated and, subsequently, aggregated to GDP. These calculations are made using two alternative quantities indices: a traditional Laspeyres quantities index and the Fisher quantities index, which takes into account the changes in relative prices when making the aggregation. The results are summarised in Table II.3.

The introduction of quality adjustments into the deflators can be seen to increase the real average growth rate of Spanish GDP by between 0.18

TABLE II.2

PRICES OF ADJUSTED ITEMS
MEAN ANNUAL RATE OF GROWTH, 1986-1994

	Consumption	Investment	Exports	Imports
Before price adjustment:				
Office machinery and computers	-1,35	-2,21	-3,75	-3,04
Precision instruments	2,49	-0,83	2,21	-1,68
Electrical and electronic equipment	0,33	1,97	1,01	2,64
Telecommunications	4,96	..	4,96	4,96
Vehicles	4,92	3,64	5,56	3,56
Residential property	..	6,23	..	..
GDP component	5,85	4,55	3,13	1,89
After price adjustment (a):				
GDP component	5,71	3,39	2,27	0,71
Memorandum item:				
Final demand deflator				
Before price adjustment	5,13			
After price adjustment (a)	4,68			
GDP deflator:				
Before price adjustment	6,03			
After price adjustment (a)	5,81			

Source: Banco de España.

(a) The correction involves the following reductions in the annual average growth rates of deflators: 10 % for office machinery and computers; 1 % for residential property; and, 2 % for the four remaining items.

and 0.22 percentage points per year, depending on whether measurement is by a Fisher or a Laspeyres quantities index, respectively. The greater increase in final demand (of between 0.32 and 0.45 percentage points) is partly offset by the strong increase (of between 0.93 and 1.29 percentage points per year) in imports. As was to be expected, given the scant weight in domestic consumption of the goods considered in this paper, a very limited effect on this component – of around one-tenth of a percentage point per year – is observed. The effects are much more notable on gross fixed capital consumption, which would have grown by around one percentage point above what the official figures currently indicate. This effect is the outcome of the greater weight of the products affected by quality changes in this component (see Table II.1). Thus, the ICT products are goods principally intended for investment, adding to which is the fact that investment in residential property, albeit with lower quality improvements, accounts for

TABLE II.3

AGGREGATE EFFECTS OF PRICE ADJUSTMENTS
MEAN ANNUAL RATE OF GROWTH AT CONSTANT PRICES, 1986-1994

	Consumption	*Investment*	*Exports*	*Final Demand*	*Imports*	*GDP*
Original prices, aggregation based on a volume index of type:						
Laspeyres (1)	3.21	4.40	8.40	4.16	10.08	2.88
Fisher (2)	3.20	4.33	8.41	4.09	10.10	2.96
Adjusted prices, aggregation based on a volume index of type:						
Laspeyres (3)	3.34	5.57	9.31	4.61	11.36	3.10
Fisher (4)	3.30	5.21	9.08	4.40	11.03	3.14
Effects of price adjustments, based on a volume index of type:						
Laspeyres (3)-(1)	0.14	1.17	0.92	0.45	1.29	0.22
Fisher (4)-(2)	0.10	0.88	0.67	0.32	0.93	0.18
Effects of price adjustments. Breakdown between total effect and index effect:						
Adjusted Laspeyres - original Laspeyres (3)-(1)	0.14	1.17	0.92	0.45	1.29	0.22
Adjusted Fisher - adjusted Laspeyres (4)-(3)	-0.04	-0.36	-0.23	3.34	-0.33	0.04
Adjusted Fisher - original Laspeyres (4)-(1)	0.09	0.81	0.69	0.24	0.95	0.26

Source: Banco de España

almost 20 % of the Spanish economy's gross fixed capital formation. The effect on investment is also notable because it affects the measurement of the economy's capital stock and, therefore, it also has a bearing on the measurement of total factor productivity. The effects on exports are less than those estimated for imports, whereby the quality adjustments introduced would increase the estimate of the trade deficit in real terms.

In sum, the estimated impact of quality adjustments on the Spanish economy's real growth rate of investment and trade flows is high. However, the impact on the real GDP growth rate is considerably lower owing, first, to the fact that the effects on consumption are scant and, further, because a high proportion of these products are from abroad. Accordingly, this translates into higher real imports, which partly offsets the estimated effects on final demand.

As to the effect of the index employed for the aggregation, it can be seen that when a Laspeyres quantities index is used, holding the weights of the baseline year fixed, the effects of these adjustments are greater. This is due to the fact that the Laspeyres index does not take into account the changes in relative prices brought about by these adjustments.

To determine the importance that consideration of these changes in relative prices may have for making the aggregation, the last three rows of Table II.3 offer a breakdown of the effects of the adjustments to the price indices, on the basis of the quantities index finally selected to make the aggregation. The last row shows the total effect of the quality adjustments on GDP growth as the difference between the growth rate of a Fisher quantities index, following hedonic quality adjustment, and the growth rate of a Laspeyres quantities index following Spanish National Accounts methodology prior to these adjustments. This total effect would, therefore, be the result of two different methodological changes: quality adjustments in prices with hedonic methods and the aggregation method. The effect due to quality adjustments – without changes in the aggregation methodology – is measured by the difference between two Laspeyres quantities indices with and without adjustments and the effect due to the index used is measured comparing the growth rates of the Fisher index and the Laspeyres index, both following adjustments. This highlights the fact that the positive effect of the quality-adjusted prices on the real growth rate is partly offset by the use of a Fisher index to aggregate, which is a more accurate procedure given the significant changes in relative prices.

Notable in connection with this breakdown is the fact that, contrary to what was expected, the index effect is positive. That is to say, after adjusting the prices for quality, the growth rate according to a Fisher quantities index is higher than the growth rate calculated on the basis of a Laspeyres quantities index. As can be seen in the first two rows of this Table, the GDP growth rate calculated on the basis of a Fisher quantities index, likewise before making any adjustment to prices, is above that calculated with a Laspeyres index. Although the adjustments to the deflators raise the growth rate of the Laspeyres index on a greater scale than for the Fisher index, they do not do so by such a sufficient amount as to estimate a negative index effect.

This result can be explained by the behaviour of imports during this period. Imports grew more in real terms than the average of the other components and their deflator less, so that on aggregating by means of a Fisher index, the weight assigned to imports is relatively lower than that in a Laspeyres index; as imports are subtracted in the calculation of GDP, their negative effect proves to be less in a Fisher index, counter-

acting the substitution effect occurring in the other expenditure components (3).

Consequently, when interpreting the estimated effects on the Spanish GDP growth rate arising from the introduction of quality adjustments, it is worth considering the difference between the growth rates of two Laspeyres quantities indices, before and after the adjustments (0.22 percentage points per year), as the result that would be obtained if INE were to commence using hedonic price indices for the goods in the sectors considered in this study but were to retain its traditional Laspeyres-type volume indices-based methodology for calculating the National Accounts aggregates. Moreover, the effect on the growth rates of a Fisher quantities index (0.18 percentage points per year) approximates to the effect arising from the adjustments to the price indices on the GDP components, net of the bias arising on the changes in the relative prices of a Laspeyres quantities index. That is to say, it can be interpreted as the hypothetical result obtained from applying the quality adjustments when the aggregation methodology had already been modified beforehand to a Fisher quantities index. Yet if, along with the hedonic adjustments, a change in the aggregation methodology towards a Fisher index were in turn introduced, the overall effect would be greater (0.26 percentage points per year) than that found when retaining a Laspeyres index as the aggregation methodology (4).

Lastly, it should be noted that this exercise analyses the average effects obtained for the period considered. Consequently, this obviates the temporary profiles of the gains in quality which, were they taken into account, would probably lead the macroeconomic effects to be greater than those obtained in the final years of the period considered, since technological advances have stepped up notably over time.

(3) It is proven that the index effect is clearly negative in each of the expenditure components, including imports, and in final demand.

(4) It should be highlighted here that in this exercise the substitution effects estimated with the Fisher index are, probably, at a lower level than those which would arise following a change in INE's aggregation methodology towards this type of index. This is because the level of disaggregation at which this exercise has been conducted is far lower than that which INE would use.

III

EXTENSIONS

III.1. Sensitivity analysis

There is a degree of uncertainty about the amount of the adjustments to apply in order to correct quality biases. There are not many empirical studies available and, moreover, they usually offer figures which differ according to the period, the specific type of product, the methodology and the country analysed. Hence the risk of making adjustments calculated for a particular country extensive to other countries which, moreover, probably differ in respect of the traditional techniques used by their statistical offices to make quality adjustments. Accordingly, it is advisable to conduct a sensitivity analysis of the results obtained in the foregoing sections by means of adopting alternative scenarios about the amount of the adjustments applied.

First, scenario A is calculated, adopting a more conservative view than that of the base scenario as to the necessary scale of the quality adjustments to the deflators of the products considered. Compared with those applied in the base exercise, the adjustments to the deflators of the products considered in this paper are reduced by half, with the exception of computers, whose deflator continues to be adjusted by 10 % per year. As previously mentioned, in this sector the empirical evidence available for any of the countries or periods considered has found the biggest difference between the performance of the hedonic price indices and that of the more traditional price indices, and this 10 % adjustment may be considered to be cautious. In scenario B, however, it is sought to simulate a level higher than the aggregate effects of the quality adjustments, and the actual adjustments applied to computers, cars and housing have been doubled in respect of the base exercise. The excessive aggregation with which expenditure on other ICT products is available in this exercise advises against raising the 2 % adjustment applied to such products in the base exercise.

TABLE III.1

SENSITIVITY ANALYSIS
AGGREGATE EFFECTS ON MEAN ANNUAL RATE OF GROWTH
AT CONSTANT PRICES, 1986-1994

	Consumption	*Investment*	*Exports*	*Final demand*	*Imports*	*GDP*
Baseline exercise						
Adjustments applied: computers -10 %, other ICT -2 %, cars -2 %, residential property -1 %						
Adjusted Laspeyres - original Laspeyres	0.14	1.17	0.92	0.45	1.29	0.22
Adjusted Fisher - original Fischer	0.10	0.88	0.67	0.32	0.93	0.18
Adjusted Fisher - original Laspeyres	0.09	0.81	0.69	0.24	0.95	0.26
Scenario A						
Adjustments applied: computers -10 %, other ICT -1%, cars -1 %, residential property -0.5 %						
Adjusted Laspeyres - original Laspeyres	0.08	0.92	0.66	0.32	1.04	0.13
Adjusted Fisher - original Fischer	0.06	0.65	0.46	0.22	0.72	0.10
Adjusted Fisher - original Laspeyres	0.05	0.58	0.47	0.14	0.74	0.18
Scenario B						
Adjustments applied: computers -20 %, other ICT -2 %, cars -4 %, residential property -2 %						
Adjusted Laspeyres - original Laspeyres	0.28	3.17	2.40	1.18	3.58	0.47
Adjusted Fisher - original Fischer	0.20	2.08	1.55	0.74	2.19	0.36
Adjusted Fisher - original Laspeyres	0.18	2.00	1.56	0.66	2.21	0.44

Source: Banco de España.

The results in Table III.1 indicate that under scenario A, where the adjustments to the deflators are lower, the real effects of the quality adjustments are still of an appreciable magnitude. The effects on the economy's investment are notable. Depending on the quantities index used in the aggregation of the real amounts, this impact ranges from 0.7 to 0.9 percentage points per year. The effect on exports stands at between 0.5 and 0.7 percentage points while the growth rate of imports increases by between 0.7 and one percentage point per year after the adjustments. The limited effects on consumption and the offsetting effect of the adjustment of imports mean that the impact on the real GDP growth rate is less, at

TABLE III.2

ADJUSTMENTS APPLIED ONLY ON COMPUTERS
AGGREGATE EFFECTS ON MEAN ANNUAL RATE OF GROWTH
AT CONSTANT PRICES, 1986-1994

	Consumption	*Investment*	*Exports*	*Final demand*	*Imports*	*GDP*
Scenario C						
Adjustments applied: computers -10 %, other sectors 0 %						
Adjusted Laspeyres - original Laspeyres	0.03	0.68	0.41	0.21	0.81	0.04
Adjusted Fisher - original Fischer	0.02	0.41	0.24	0.12	0.51	0.03
Adjusted Fisher - original Laspeyres	0.01	0.34	0.26	0.04	0.54	0.10
Scenario D						
Adjustments applied: computers -20 %, other sectors 0 %						
Adjusted Laspeyres - original Laspeyres	0.12	2.46	1.58	0.79	2.91	0.17
Adjusted Fisher - original Fischer	0.06	1.33	0.84	0.42	1.61	0.09
Adjusted Fisher - original Laspeyres	0.05	1.26	0.85	0.35	1.63	0.17

Source: Banco de España

between 0.1 and 0.13 percentage points a year, depending on the aggregation index. Lastly, the joint effect of the quality adjustments and the change in aggregation index would amount to 0.18 points per year. Under scenario B, where quality adjustments have been doubled in computers, cars and housing, the impact on economic magnitudes in real terms is most substantial. The GDP growth rate would increase by almost half a percentage point per year, with the annual growth rates for investment, exports and imports rising by more than two percentage points following quality adjustments. This sensitivity analysis thus gives us some idea of the range of expected effects on the real growth of the Spanish economy in terms of the magnitude of the adjustments applied to price indices to accommodate product quality changes.

It is worth verifying how the aggregate effects of quality adjustments in a single sector may be relevant when the quality improvements in the sector are of some size. To this end, computers have been selected since there is broad consensus about the significant quality improvements they have undergone. Table III.2 shows the results of considering solely adjustments to the deflator for computers. In an initial exercise, in

TABLE III.3

AGGREGATE EFFECTS OF ADJUSTMENTS IN PRICE INDICES
MEAN ANNUAL RATE OF GROWTH AT CONSTANT PRICES, 1986-1994

	Consumption	*Investment*	*Exports*	*Imports*	*GDP*
Adjusted Laspeyres - original Laspeyres	0.08	0.88	0.59	1.05	0.10
Adjusted Fisher - adjusted Laspeyres	-0.04	-0.38	-0.20	-0.30	0.04
Adjusted Fisher - original Laspeyres	0.05	0.50	0.39	0.75	0.15

Source: Banco de España

scenario C, a 10 % adjustment is applied to the growth rate of the deflator for this sector, while this adjustment is doubled to 20 % in scenario D. In scenario C the estimate of the real GDP growth rate would increase very slightly by between 0.03 and 0.04 percentage points a year. Nonetheless, the effect on the growth of investment or trade flows are far from negligible. Scenario D shows that when the quality adjustments in the IT sector are intense, the aggregate effects may be significant. The upward revision of the estimated growth rate of investment and of imports might exceed two percentage points a year. However, the effects on the real GDP growth rate – which would increase by between 0.09 and 0.17 percentage points per year – are moderate.

III.2. International comparison

The differential response of the Spanish economy to an international phenomenon, namely product quality improvements, is worthy of analysis. This differential response will essentially reflect the different structure of Spanish demand and the different degree of technological dependence in these products. To this end, the study by Schreyer (1998) for five OECD countries (Canada, France, Japan, the Netherlands and the United States) is replicated. The study simulates the real growth rates of GDP components derived from making the same quality adjustments to the prices of ICT goods and services for all five countries. The adjustments are: –10 percentage points in computers and semiconductors and –2 percentage points in other ICT. It has not been possible in Spain's case to segregate semiconductors; a somewhat broader range of products had to be taken, namely the entire electrical and electronic equipment branch.

TABLE III.4

INTERNATIONAL COMPARISON OF AGGREGATE EFFECTS OF ADJUSTMENTS IN PRICE INDICES MEAN ANNUAL RATE OF GROWTH AT CONSTANT PRICES

	Private consumption	*Government consumption*	*Investment*	*Exports*	*Imports*	*GDP (a)*
Canada, 1986-1992						
Adjusted Laspeyres - original Laspeyres	0.09	0.10	0.85	0.73	1.28	0.03
Adjusted Fisher - adjusted Laspeyres	-0.08	-0.12	-0.44	-0.45	-0.62	-0.06
Adjusted Fisher - original Laspeyres	0.02	-0.01	0.41	0.28	0.66	-0.03
France, 1985-1996						
Adjusted Laspeyres - original Laspeyres	0.11	0.00	0.91	0.58	0.67	0.21
Adjusted Fisher - adjusted Laspeyres	-0.07	-0.01	-0.23	-0.15	0.03	-0.08
Adjusted Fisher - original Laspeyres	0.04	-0.01	0.68	0.43	0.71	0.13
Japan, 1985-1994						
Adjusted Laspeyres - original Laspeyres	0.13	0.00	1.32	2.61	0.88	0.73
Adjusted Fisher - adjusted Laspeyres	-0.13	1.13	-0.88	-1.60	-0.41	-0.26
Adjusted Fisher - original Laspeyres	0.01	1.13	0.44	1.01	0.47	0.47
Netherlands, 1986-1993						
Adjusted Laspeyres - original Laspeyres	0.12	0.00	1.36	0.96	1.31	0.27
Adjusted Fisher - adjusted Laspeyres	-0.31	-0.01	-0.65	-0.41	-0.65	-0.31
Adjusted Fisher - original Laspeyres	-0.18	-0.01	0.71	0.56	0.67	-0.05
United States, 1987-1993						
Adjusted Laspeyres - original Laspeyres	0.10	0.19	1.56	0.97	1.29	0.29
Adjusted Fisher - adjusted Laspeyres	-0.08	-0.04	-0.65	-0.45	-0.56	-0.15
Adjusted Fisher - original Laspeyres	0.03	0.15	0.91	0.53	0.73	0.14

Source: Schreyer (1998).
(a) Changes in stocks are not included in GDP.

Table III.3 offers the results obtained for Spain once the set of sectors considered has been confined to ICT products to make the comparison with the results obtained by Schreyer (1998), and which are set out in Table III.4. Comparison of both tables shows that quality adjustment in ICT products, without altering the type of index used (Laspeyres), has a comparatively low effect in the Spanish case, the lowest of all in fact except for Canada. Thus, while the effect on Spanish GDP is quantified as 0.1 percentage points, in France it is double and in the Netherlands and the United States triple this, rising to 0.7 percentage points in Japan. This result is largely due to greater technological dependence and to the relatively low weight of investment in these types of goods. Indeed, the biggest differences are in investment, the adjustment of which in Spain is significantly less than in the three latter countries. The greater relative weight of these types of goods in Japan is because this country is impacted to a far greater extent than the other countries. Notably, the scale of the effect on consumption in all countries is far less than that on the other GDP components.

If what is compared is the aggregate impact of making quality adjustments to ICT products and of simultaneously modifying the index used (substituting a Laspeyres for a Fisher index), the effect on Spanish GDP is greater than that obtained for Canada and the Netherlands, similar to that for France and the United States, but less than that for Japan.

Elsewhere, EUROSTAT (1999) estimated how much the GDP growth rate would rise if a 10 % quality adjustment were introduced into the deflators for computers in the year 1991 for Germany, France and the Netherlands. Its results are comparable, although somewhat greater than those obtained here for Spain, 0.04 percentage points (Table III.2, first line of scenario C), as they are 0.06 percentage points for France, 0.13 percentage points for the Netherlands and 0.15 percentage points for Germany.

IV

CONCLUSIONS

Insofar as the traditional techniques used to construct price indices are not capable of separating the pure change in prices from the change brought about by alterations in product characteristics that increase their quality, price growth will be overestimated and, as a consequence, the estimate of the macroeconomic magnitudes at constant prices will be lower. Given the rapid technological progress in recent years, this circumstance has become a focus of particular interest. This paper has attempted to illustrate the magnitude of the bias incurred in the estimation of the real growth rate of GDP and its components owing to the lack of price adjustment for product quality changes.

In this connection, an evaluation has been made of the consequences of introducing quality adjustments into a set of sectors where these quality changes have been prominent. The international evidence pinpoints the ICT sector's set of goods and services as that where the measurement problems associated with quality changes are most telling. In addition, the housing and car manufacturing sectors have been considered as they have a particularly significant weight in the Spanish economy and because they have undergone substantial quality improvements in recent years. Drawing on the empirical studies available for other countries, generally for the United States, the price growth rates in these sectors have been adjusted by a factor that captures the insufficiently discounted quality adjustments, thereby obtaining adjusted growth rates for the deflators and for real expenditure for each of these products. As these rates are aggregated, they give rise to an upward estimate of the Spanish economy's real growth figures.

The results of the paper should be viewed with caution for several reasons. First, it is confined to the sectors where quality improvements may have been most substantial, but the gains in quality that may have occurred in the rest of the economy are not taken into account. Yet nor is

regard had to the losses in quality that may have taken place in certain goods and services and which could offset, at least in part, the lack of adjustment for quality improvements in other sectors of the economy. In any event, it is not possible with the information available to quantify the net effect; moreover, statistical limitations make it very difficult to perform an exercise including all sectors of the economy. Lastly, the adjustments applied to contemplate changes in quality have not been calculated specifically for Spain but have been drawn from the analysis of the evidence available for other countries. Overall, therefore, this exercise does not offer an accurate estimate of the corrections, derived from quality-adjusted price indices, to the real growth rates of Spanish macroeconomic aggregates. However, it does highlight the quantitative and qualitative relevance these adjustments may have, providing information on the magnitude of the foreseeable impact on the growth rates of the deflators and of real GDP.

Bearing these caveats in mind, the annual average real GDP growth rate during the period 1986-1994 would be re-estimated upwards by two-tenths of a point following the quality adjustments to the price indices of the sectors considered. By GDP component, the effects of these adjustments are particularly significant in investment, exports and imports, and are low in the case of domestic consumption. The impact on investment is notable since it affects the estimate of the economy's capital stock and has implications, therefore, for the analysis of economic growth as it affects the estimate of total factor productivity. In these calculations, the type of quantities index used in the aggregation of the real amounts is a significant element. Given the marked changes in relative prices prompted by the adjustments to price indices, the substitution bias incurred with a Laspeyres quantities index translates into an over-estimation of the aggregate effects of the adjustments. A Fisher quantities index, which takes these changes in relative prices into account, slightly reduces the estimated effects (the effect on the GDP growth rate falls to 0.18 percentage points per year compared with the 0.22 points estimated with a Laspeyres index).

The sensitivity analysis conducted shows that, under different assumptions, the estimated effects are, in any event, relevant in estimating the growth rate of investment and of trade flows, although the impact on GDP may prove to be on a much lower scale. These effects are qualitatively and quantitatively comparable to those estimated for other countries. In this respect, although the estimated magnitude of these measures and biases may not explain, for example, the growth differentials observed in recent years between the US and European economies, it is advisable to focus attention on the significance of the measurement problems associated with quality changes when international comparisons are

made between countries whose methodology for constructing quality-adjusted price indices differs.

With the availability in the near future of specific studies (1) for the Spanish economy on the magnitude of quality biases in the sectors considered, the estimates presented in this paper may be revised. Further, it is also planned to perform a similar exercise for the period 1995-99 based on National Accounts information, allowing assessment of the extent to which the study of a more recent period prompts changes in the estimates presented. In principle, given the growing importance of ICT in recent years and the empirical evidence available for the United States, which appears to indicate that the speed of quality improvements has increased (2), quality adjustments to price indices based on more recent information will foreseeably have a greater impact on the economy's real growth rates.

(1) As part of the research project on the problems derived from quality changes, estimates of hedonic price indices for computers, cars and housing will be made. See Banco de España (2001).

(2) See Berndt, Dulberger and Rappaport (2000).

REFERENCES

ARÉVALO, R. (1998). *Caracterización de la vivienda y determinación de su valor corriente (1980-1990),* Documento de Trabajo ICAE nº 9810, Universidad Complutense.

BANCO DE ESPAÑA (2001). "Los cambios en la calidad y la aparición de nuevos productos: importancia de su valoración para la política económica", *Boletín Económico,* enero.

BERNDT, E. R., DULBERGER, E. R. and RAPPAPORT, N. J. (2000). "Price and Quality of Desktop and Mobile Personal Computers: A Quarter Century of History", July, mimeo.

BOSKIN, M., DULBERGER, E., GORDON, R., GRILICHES, Z. and JORGENSON, D. (1996). *Toward a More Accurate Measure of the Cost of Living,* Final Report to the Senate Committee.

BOVER, O. and IZQUIERDO, M. (2001). *Quality-adjusted prices: hedonic methods and implications for National Accounts,* Serie Estudios Económicos, no. 70, Servicio de Estudios, Banco de España.

EUROSTAT (1999). *Report of the Task Force Volume Measures for Computers and Software,* June, Luxembourg.

GORDON, R. J. (1990). *The Measurement of Durable Goods Prices,* The University of Chicago Press.

LANDEFELD, S. and GRIMM, B. T. (2000). "A Note on the Impact of Hedonics and Computers on Real GDP", *Survey of Current Business,* December.

SCHREYER, P. (1996). "Quality Adjustment of Price Indices in Information and Communication Technology Industries: Simulation of Effects on Measured Real Output in Five OECD Countries", in *Industry Productivity: International Comparison and Measurement Issues,* OECD Proceedings.

— (1998). *Information and Communication Technology and the Measurement of Real Output, Final Demand and Productivity,* OECD Working Papers no. 54.

TRIPLETT, J. (1989). "Price and Technological Change in a Capital Good: a Survey of Research on Computers", en Jorgenson and Landau (eds.),*Technology and Capital Formation,* MIT Press.

— (1996). "High-tech Industry Productivity and Hedonic Price Indices" in *Industry Productivity: International Comparison and Measurement Issues,* OECD Proceedings.

WYCKOFF, A. W. (1995). "The Impact of Computer Prices on International Comparisons of Labor Productivity", *Economic Innovation and New Technology,* vol. 3.

APPENDIX I

ACCOUNTING FRAMEWORK

For each GDP component, the value in current prices of the annual expenditures on each of the products whose prices are to be adjusted is needed, Y^g_{kt}, where k = 1,…,K, are the products considered and g = C, I, X, M, where C denotes domestic consumption, I gross fixed capital formation (1), X exports and M imports. This information is obtained from the 1986-based National Accounts IOT (specifically from the tables on total end-use, end-use of domestic production and end-use of imports), which offer information with a breakdown into 56 productive branches for the period 1986 to 1994; as will be detailed below, it will occasionally be necessary to resort to supplementary statistical sources to arrive at the desired level of disaggregation.

Having obtained the desired breakdown identifying nominal expenditure on each of the K products, for each GDP component, such expenditure must be expressed in real terms. The IOT are only available in nominal values, various price indicators to deflate nominal expenditure have been used, depending on the product and on the GDP component (see Appendix II). Thus, the following amounts have been obtained:

$$q^g_{kt} = \frac{Y^g_{kt}}{P^g_{kt}}$$

where P^g_{kt} is the deflator of product k in GDP component g, in period t, and q^g_{kt} is the value of expenditure in real terms. Some of the price indicators for the K products are Laspeyres indices, while the National Ac-

(1) As detailed below, a distinction has been made in gross fixed capital formation between that of domestic and that of foreign origin. But in order to simplify the notation here, this breakdown is not made explicit. Note that this breakdown is not needed in the case of domestic consumption, because the indicators used include both domestic and foreign products.

counts deflators are Paasche indices. In such cases the deflator has been calculated by the formula:

$$P^{g}_{kt} = \frac{H^{g}_{kt}}{H^{g}_{kt-1}} 100$$

where H^{g}_{kt} is the average value in year t of the price indicator for product k, for the GDP component g.

For the remaining items of each component g, which are not part of the products affected by the correction of quality biases, a deflator, P^{g}_{Rt}, has been calculated as a difference, which is no more than:

$$P^{g}_{Rt} = \frac{P^{g}_{t} - \sum_{K} \alpha^{g}_{kt-1} P^{g}_{kt}}{1 - \sum_{K} \alpha^{g}_{kt-1}}$$

where P^{g}_{t} is the National Accounts deflator of component g and $\alpha^{g}_{kt-1} = \frac{Y^{g}_{kt-1}}{g_{t-1}}$ is the weight of each product k in that component.

Once the foregoing information is available, the desired adjustments can be made to the deflators of each of the K products, reducing their annual growth rate $\pi^{g}_{kt_1}$ by λ_k percentage points, between the initial year , t_0, and the final year, t_1, of the exercise (2).

$$P^{g}_{kt_1} = P^{g}_{kt_0}\left(1 + \pi^{g}_{kt_1}\right)^{(t_1 - t_0)}$$

$$\tilde{P}^{g}_{kt_1} = P^{g}_{kt_0}\left[1 + \left(\pi^{g}_{kt_1} - \lambda_k\right)\right]^{(t_1 - t_0)}$$

The adjusted deflators $\tilde{P}^{g}_{kt_1}$ enable the real expenditure on each product k for each GDP component to be re-calculated.

$$\tilde{q}^{g}_{kt_1} = \frac{Y^{g}_{kt_1}}{\tilde{P}^{g}_{kt_1}}$$

By construction $P^{g}_{kt_1} > \tilde{P}^{g}_{kt_1}$ whereby $q^{g}_{kt_1} < \tilde{q}^{g}_{kt_1}$.

(2) The study spans the period from 1986 to 1994, but the simulation could be made for a specific sub-period.

To calculate the effect arising from the adjustment for changes in quality to the real growth rate of each of the GDP components, the new values of the components are calculated in real terms, adjusted for changes in quality and expressed as an index number, $\tilde{g}_L$:

$$\tilde{g}_L = \frac{\sum_{k=1}^{K} P^g_{kt_0} \tilde{q}^g_{kt_1} + \sum_{j \neq k} P^g_{jt_0} \tilde{q}^g_{jt_1}}{\sum_{k=1}^{K} P^g_{kt_0} q^g_{kt_0} + \sum_{j \neq k} P^g_{jt_0} q^g_{jt_0}} \qquad g = C, I, X \text{ y } M$$

This aggregation is made using Laspeyres indices – i.e. the weights of each product are based on the initial year – as corresponds to the National Accounts quantities indices. From the ratio $\tilde{g}_L$ / g_L for each of the adjusted and non-adjusted GDP components, we obtain the effect arising from the quality adjustment in these components (3).

To avoid the substitution bias to which a Laspeyres index is subject when there are changes in relative prices, a Fisher index is preferable, defined as the geometric mean of the Laspeyres index and the Passche index, and which allows this substitution process to be taken into account. The Paasche index is calculated at end-year prices.

$$\tilde{g}_P = \frac{\sum_{k=1}^{K} \tilde{P}^g_{kt_1} \tilde{q}^g_{kt_1} + \sum_{j \neq k} P^g_{jt_1} q^g_{jt_1}}{\sum_{k=1}^{K} \tilde{P}^g_{kt_1} q^g_{kt_0} + \sum_{j \neq k} P^g_{jt_1} q^g_{jt_0}} \qquad g = C, I, X \text{ y } M$$

Consequently, the Fisher index is calculated as:

$$\tilde{g}_F = \sqrt{\tilde{g}_L \tilde{g}_P} \qquad g = C, I, X \text{ y } M$$

For each GDP component, the effect of replacing the Laspeyres index by a Fisher index is $\tilde{g}_F$ / $\tilde{g}_L$.

Lastly, the aggregate effect on the growth of the economy is computed in the same way as for each of the components, distinguishing between the effect attributable to the quality-change adjustment and the effect due to the use of a Fisher index.

(3) As what is sought is to learn how quality changes may have affected the growth of the macroeconomic variables, in the exercise the effect is computed as the difference between the adjusted and non-adjusted growth rates.

APPENDIX II

INFORMATION USED

To identify the products whose prices require adjusting for quality changes, it is necessary to move to a substantially disaggregated level in terms of productive branches. The breakdown into 56 branches offered by the National Accounts 1986-based IOT is not sufficient in certain cases. The products identified as belonging to the ICT sector (1) are included in the branches 230 (office and data processing machinery and other precision instruments), 250 (electrical and electronic equipment) y 670 (communications services). The manufacture of vehicles is branch 270 and housing is in branch 530 (construction). Nonetheless, these branches are too aggregated for conducting the exercise: specifically, for three of them (230, 530 and 670) a greater breakdown is needed. This has been obtained from information from supplementary statistical sources, whose percentage structures have been used to disaggregate the nominal amounts of these three IOT branches.

To break consumer expenditure down, the Spanish Quarterly Family Expenditure Survey (ECPF) has been used. As regards gross fixed capital formation, a distinction has been made between that of domestic and that of foreign origin. In particular, for that of domestic origin, the information provided by the Industrial Survey (EI) or Spanish National Accounts (CNE) has been used. Customs Records (RA) have been used to break down foreign gross fixed capital formation, along with imports and exports. Given the range of statistical sources needed, the level of disaggregation arrived at has been conditional upon information availability and the consistency of each source.

(1) The goods and services forming part of ICT are defined in accordance with Schreyer (1998).

TABLE A.II.1

BREAKDOWN OF THE VARIOUS IOT BRANCHES BY GDP COMPONENT

IOT branch breakdown (56 branches)	*Domestic consumption (Source: ECPF)*	*Domestic gross fixed capital formation (Sources: EI and CNE) Sector NACE-74*	*Foreign gross fixed capital formation, exports and imports (Source: RA)*
230 Office and data processing machinery and other precision instruments	— Personal computers, videos and electronic games — Typewriters (included in Musical instruments, boats and other goods)	Sector 33, Office and data processing machinery (EI)	Sector 11, Computer and office equipment
	— Surgical equipment and orthopaedic appliances — Photographic, film and projection equipment	Sector 39, Precision, measuring and control instruments (EI)	Sector 15, Precision instruments
250 Electrical and electronic equipment	No further breakdown	No further breakdown	No further breakdown
670 Communications services	— Post and telegraphy	(a)	(b)
	— Telephony	(b)	(b)
270 Manufacture of motor cars and engines	No further breakdown	No further breakdown	No further breakdown
530 Construction	(a)	— Residential property (CNE)	(a)
		— Other	

Source: Banco de España.
(a) There is no expenditure on this productive branch.
(b) This expenditure is assumed to relate in its entirety to telecommunications.

The second column of Table A.II.1 details the information from the ECPF used to disaggregate the IOT expenditure on domestic consumption relating to branches 230 and 670. Branch 230 is broken down into office machinery and computers, and precision instruments. As Table A.II.1 shows, both categories are the result of adding together several family expenditure items. Branch 670 is broken down into postal services and telecommunications services. As to branch 530, although in domestic consumption there is minor expenditure on this item relating to small home repairs, it has not been deemed appropriate to adjust it for quality changes.

The third column of Table A.II.1 contains the breakdown of domestic gross fixed capital formation spending of the IOT. As with the segregation

made for domestic consumption expenditure, on this occasion, with the EI, a distinction is made in branch 230 between office and data processing machinery (sector 33 of NACE-74) and precision, measurement and control instruments (sector 39). Branch 530 is, with the help of Spanish National Accounts (CNE), broken down into residential property and other. As to branch 670, there is no expenditure on this component.

The items relating to foreign gross fixed capital formation, imports and exports of the 56-branch IOT are broken down on the basis of the disaggregated information from Customs Records. As can be seen in the fourth column of Table A.II.1, this information allows branch 230 expenditure to be broken down into IT and office equipment, and precision instruments, but not so branch 670. In the absence of an indicator, it has been assumed that branch 670, communications services, relates in its entirety to telecommunications services. Lastly, in the foreign sector there is no expenditure in branch 530 and the expenditure in this branch on gross fixed capital formation is domestic.

Charts A.II.1 to A.II.6 show the structure obtained for the IOT branches that have been broken down (230, 530 and 670), for each GDP component.

As earlier indicated, no deflators are available within the IOT accounting framework; therefore, deflators have been constructed for each component and each product drawing on the price indicators closest to CNE methodology. The CNE implicit deflators have been used for the GDP components. Table A.II.2 shows the set of price indicators used for each disaggregated item. For domestic consumption expenditure, resort has been had to the sub-classes of the consumer price index (CPI) (2); the domestic gross fixed capital formation in these products has been deflated using the producer price indices (PPI), except for residential property, for which the related Spanish National Accounts implicit deflator is available. Foreign gross fixed capital formation, imports and exports have been deflated using the related unit value indices (UVI). As no UVI is

(2) The 1983 and 1992 CPI bases have been joined beforehand. As the first available figure of the 1983-based CPI is that of August 1985, the deflator of the items affected by quality changes in the year 1986 has been calculated as the observed average growth of the corresponding CPI items between August and December 1986 compared with the same period a year earlier. In turn, although telegraphy has not been included in telecommunications domestic consumption expenditure, its prices are in fact included in the estimated deflator, since the information available does not allow this incongruence to be circumvented; foreseeably, given the limited weight of telegraphy, the distortion will not be considerable.

TABLE A.II.2

PRICE INDICATORS OF PRODUCTS AFFECTED BY QUALITY CHANGES

Description	*Domestic consumption indicator* *(Source: CPI)*	*Domestic gross fixed capital formation indicator* *(Source: PPI)* (a)	*Indicator of foreign gross fixed capital formation, exports and imports* *(Source: UVI)* (a)
Office machinery and computers	Personal computers, typewriters and other (b)	Construction of office equipment and computers	IT and office equipment
Precision instruments (c)	— Equipment and therapeutic appliances — Photographic equipment and appliances	Manufacture of precision, optical and similar instruments	Precision instruments
Electrical and electronic equipment (c)	— Household appliances — Radios — Televisions — Other video and sound equipment	— Construction of machinery and electrical equipment — Manufacture of electronic equipment (except computers)	Electrical and electronic machinery
Telecommunications	Telephony and telegraphy service	(d)	CPI of telephony and telegraphy service
Vehicles	— Motor vehicles — Other vehicles — Parts, spare parts and accessories	Construction of motor vehicles and their spare parts	Vehicles
Residential property	(d)	Implicit deflator of Residential property in Spanish National Accounts	(d)

Source: Banco de España.
(a) Unless otherwise indicated.
(b) For before 1993 the series is “Other leisure goods” from the 1983-based CPI.
(c) When several series are broken down, the indicator is the weighted average thereof.
(d) There is no expenditure in this productive branch.

available for telecommunications services, these have been deflated with the CPI sub-class of telephony and telegraphy services.

BREAKDOWN OF IOT BRANCHES IN NOMINAL TERMS

CHART A.II.1

BREAKDOWN OF BRANCH 230 ACCORDING TO THE ECPF

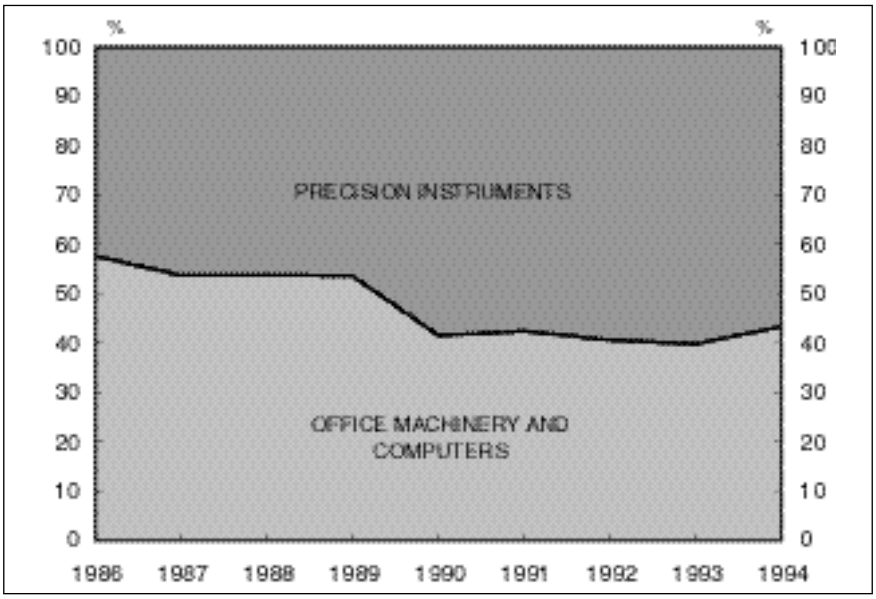


CHART A.II.2

BREAKDOWN OF BRANCH 670 ACCORDING TO THE ECPF

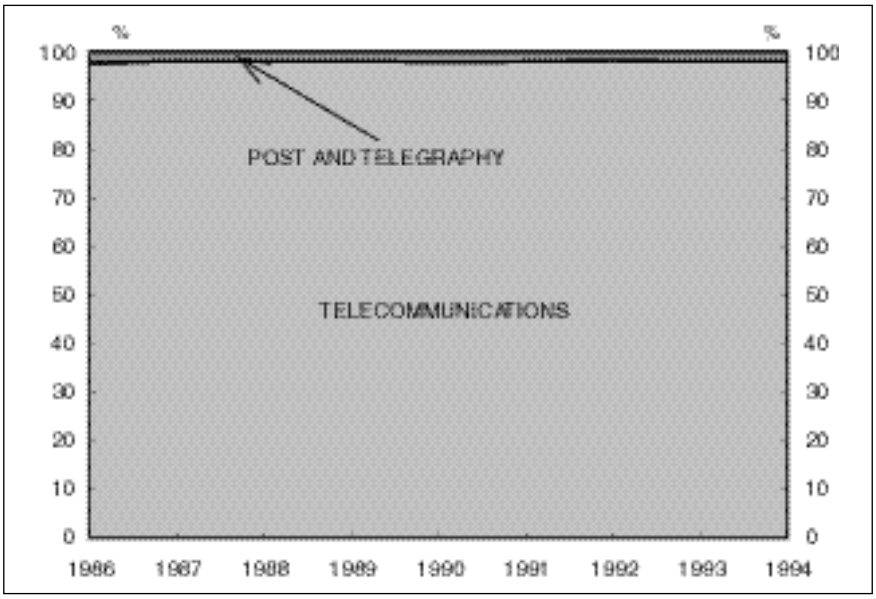


CHART A.II.3

BREAKDOWN OF BRANCH 230 ACCORDING TO THE INDUSTRIAL SURVEY

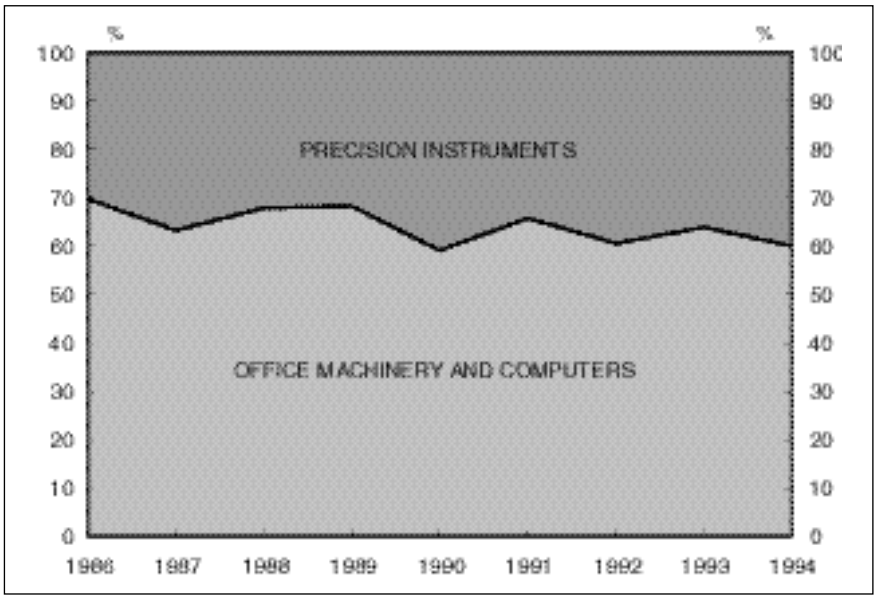


CHART A.II.4

BREAKDOWN OF EXPORTS IN BRANCH 230 ACCORDING TO CUSTOMS RECORDS

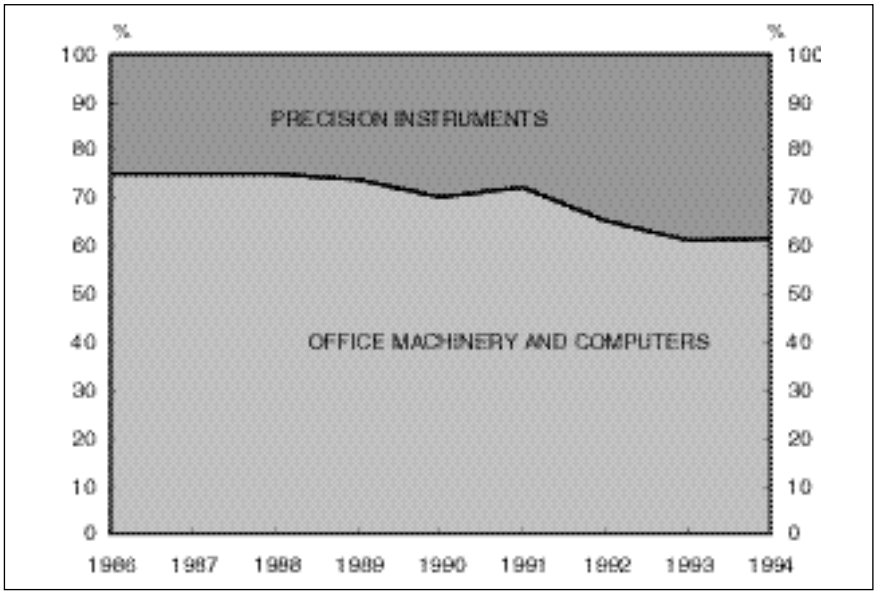


CHART A.II.5

BREAKDOWN OF IMPORTS AND INVESTMENT OF FOREIGN ORIGIN IN BRANCH 230 ACCORDING TO CUSTOMS RECORDS

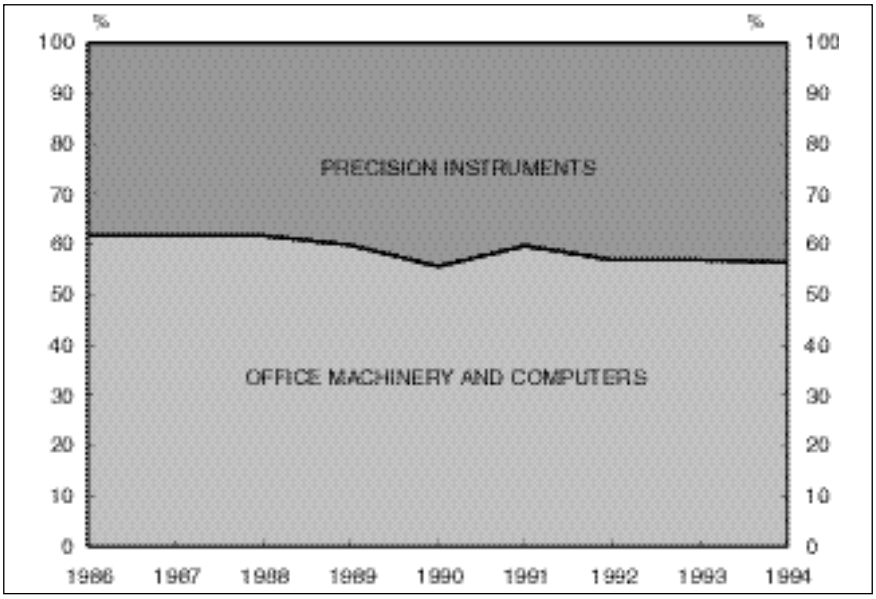
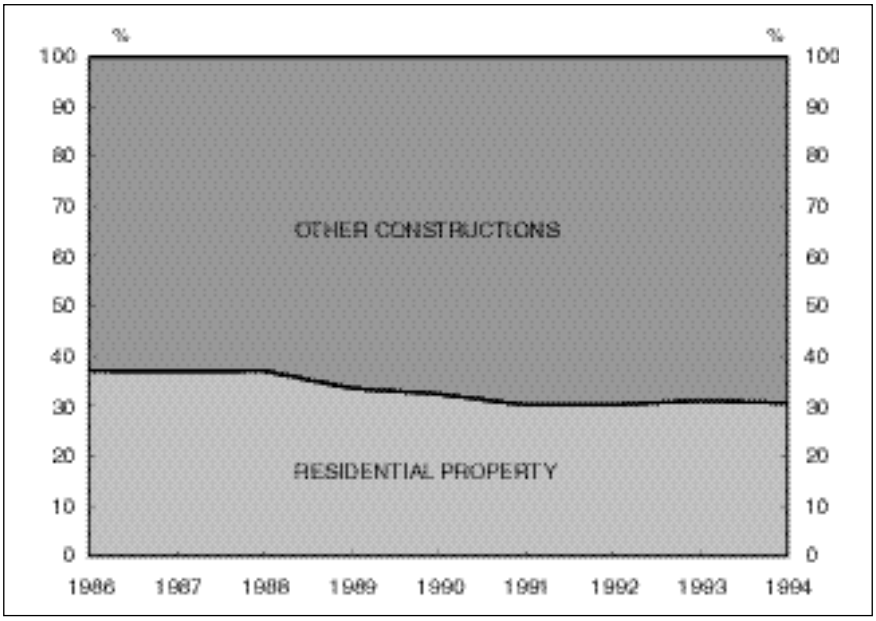


CHART A.II.6

BREAKDOWN OF BRANCH 530 ACCORDING TO THE CNE



APPENDIX III

ADDITIONAL TABLES

TABLE A.III.1

**ITEMS INCLUDED IN THE ADJUSTMENTS.
PERCENTAGE OF TOTAL AT 1986 CONSTANT PRICES.
OFFICIAL PRICES**

Items	*Consumption*		*Investment*		*Exports*		*Final demand*		*Imports*		*GDP*	
	1986	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*
Office machinery and computers	0.15	0.18	3.21	3.95	1.60	2.16	0.85	1.17	3.94	4.36	0.33	0.23
Precision instruments	0.11	0.17	1.78	2.65	0.53	0.84	0.45	0.71	2.44	3.02	0.11	0.04
Electrical and electronic equipment	0.97	1.32	6.03	7.03	3.52	6.52	2.15	3.19	6.84	7.58	1.35	1.91
Telecommunications	0.64	0.91	0.00	0.00	0.72	0.36	0.54	0.68	0.16	0.18	0.61	0.80
Vehicles	2.36	2.46	6.37	6.30	11.38	15.49	4.17	5.35	6.83	11.10	3.72	3.68
Residential property	0.00	0.00	19.36	16.52	0.00	0.00	3.31	2.84	0.00	0.00	3.87	3.67
Total	4.23	5.03	36.75	36.45	17.75	25.37	11.48	13.92	20.21	26.23	9.99	10.33

Source: Banco de España

TABLE A.III.2

ITEMS INCLUDED IN THE ADJUSTMENTS.
PERCENTAGE OF GDP COMPONENT AT CONSTANT PRICES.
ADJUSTED PRICES

Items	*Consumption*		*Investment*		*Exports*		*Final demand*		*Imports*		*GDP*	
	1986	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*	*1986*	*1994*
Office machinery and computers	0.15	0.41	3.21	8.61	1.60	4.90	0.85	2.71	3.94	9.60	0.33	0.56
Precision instruments	0.11	0.20	1.78	2.86	0.53	0.91	0.45	0.81	2.44	3.28	0.11	0.04
Electrical and electronic equipment	0.97	1.53	6.03	7.56	3.52	7.08	2.15	3.63	6.84	8.17	1.35	2.22
Telecommunications	0.64	1.05	0.00	0.00	0.72	0.38	0.54	0.74	0.16	0.19	0.61	0.92
Vehicles	2.36	2.83	6.37	5.78	11.38	16.72	4.17	5.19	6.83	10.21	3.72	3.63
Residential property	0.00	0.00	19.38	15.15	0.00	0.00	3.31	2.75	0.00	0.00	3.87	3.61
Total	4.23	6.01	36.76	39.97	17.76	30.01	11.48	15.85	20.21	31.44	9.99	10.98

Source: Banco de España.

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